The development of speechreading in deaf and hearing children: introducing a new Test of Child Speechreading (ToCS)

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Abstract

This paper describes the development of a new Test of Child Speechreading (ToCS) that was specifically designed to be suitable for use with deaf children. Speechreading is a skill which is required for deaf children to access the language of the hearing community. ToCS is a child-friendly, computer-based, speechreading test that measures speechreading (silent lipreading) at three psycholinguistic levels: words, sentences and short stories. A detailed description of the design, procedure and validity of ToCS is provided. 86 severely and profoundly deaf and 91 hearing children aged between 5 and 14 years participated in the standardisation study. Deaf and hearing children showed remarkably similar performance across all subtests on ToCS. Speechreading improved with age but was not associated with non-verbal IQ. For both deaf and hearing children, performance on ToCS was significantly related to reading accuracy and reading comprehension.

Index Terms: speechreading, deafness, language, reading, assessment

1 Introduction

For many deaf children, speechreading (silent lipreading) is the main access to the spoken language of the hearing community. Speechreading has often been found to be associated with levels of reading ability in deaf children, but mainly for those in oral education settings (e.g. [1, 2, 3]). More recent research, however, has found speechreading to be a strong longitudinal predictor of deaf children's reading development - regardless of language preference [4]. Moreover, speechreading has also been linked with literacy skills in beginning hearing readers [5]. Interestingly, hearing children have often been reported as having at least equivalent, if not better, speechreading skills than deaf children (e.g. [1, 6]). This viewpoint was challenged by the results of a recent adult study [7] in which profoundly deaf adults were found to be better speechreaders than hearing adults when assessed using a deaf friendly speechreading test, measuring speechreading at different psycholinguistic levels. Furthermore, speechreading was significantly associated with reading comprehension in these deaf adults.

The existing developmental research is somewhat limited due to relatively small sample sizes and that the relationship between speechreading and reading has predominately only been measured at the single word level. Given the recent research findings in both children and adults, and the limitations to extant developmental speechreading tests, a new Test of Child Speechreading (ToCS) was designed to examine the developmental trajectory of speechreading at different psycholinguistic levels and to further investigate its importance for literacy.

2 Test of Child Speechreading (ToCS)

2.1 Aims of ToCS

The main aim was to develop a test of speechreading (silent lipreading) for children aged between 5 and 14 years that would (1) be sensitive enough to measure individual differences in performance, (2) be able to map the developmental trajectory of speechreading and (3) be suitable for use with both deaf and hearing children.

2.2 Design of ToCS

ToCS is a computer-based, video-to-picture matching speechreading test. A brightly coloured, child-friendly interface was specifically designed in order to present the test in a game format. ToCS is easy to administer and provides a snapshot of speechreading ability in approximately 20 minutes. ToCS contains three subtests that measure speechreading skills at three different psycholinguistic levels: Words, Sentences and Short Stories.

2.3 ToCS content

The test was specifically designed so that the lexical content was appropriate for use with deaf children. All items were of early age of acquisition and highly frequent (according to hearing norms) and were easily represented pictorially. Initially, a small pilot study was conducted with deaf and hearing children to ensure that the chosen items were familiar. After both the pilot study and a discussion with several teachers of the deaf over the suitability of the content, several items were removed and the number of experimental trials was reduced to 15.

Participants respond by selecting the correct item from an array of 4 pictures (the target and 3 distractors). In the Words subtest, the three distractors were related to the target in terms of visemic properties whereby they either shared the same initial viseme, final viseme or vowel sound. For example, the distractors for the target door were duck, fork and dog. Each picture array was presented on a new screen with 3 pre-specified novel distractors. The 15 target sentences in the Sentences subtest each contained one of the 15 words from the Words subtest. The majority of the distractor pictures for the Sentences subtest were generated by showing the silent video clips to several deaf and hearing adults and children and asking what they thought had been said. The remaining distractors shared similar features to the target. For example, the distractors for the target "the baby is in the bath" were pictures representing an elephant having a bath, a baby reading a book and some pigs on a path (see Figure 1). The distractors for the Story subtest were alternate viable answers to the questions asked.

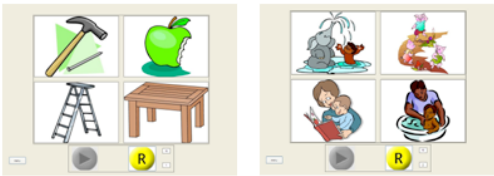

Figure 1: Examples of response screens for the target word APPLE and the target sentence THE BABY IS IN THE BATH

2.4 Speakers

There were two speakers: a male Caucasian and a female of Sri Lankan descent. They were both native speakers of English with Received Pronunciation (RP), and had clear articulation and good voice quality. They were judged by several deaf and hearing adults to be relatively easy to speechread. During the recording, the speakers were asked to speak normally and all items were recorded audio-visually. The sound levels for the video clips were normalised during the editing process. See Figure 2 for still video clips of the speakers.

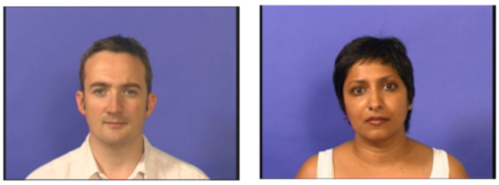

Figure 2: Video stills of the two speakers

2.5 Procedure for ToCS

The participants initially watched a short, silent familiarisation video in which both speakers said the days of the week. All video clips were played without sound. There were practice trials at the beginning of each section, during which the participants received feedback. No feedback was provided during the test trials. Within each subtest, the order of presentation of trials was randomised although the male and female speakers were alternately counterbalanced. The instructions for each subtest were presented on the screen and delivered by the tester in the participant's preferred language; speech, BSL or a combination of both. The instructions had specifically been designed to be equivalent regardless of the language in which they were presented.

2.5.1 Words and Sentences subtests

There were 15 items in each of the Words and the Sentences subtests. On each trial, the participant saw a silent video clip of either the male or female speaker saying the target item (word or sentence depending upon the subtest). Then the participant saw an array of four pictures and had to click on the picture that best matched what they had seen. The following instructions were given "The man or woman will say a word (or sentence). Then you will see four pictures. You have to click the picture that matches what you saw. We will practice first." Each trial was presented on a new screen. Each picture array contained the target and 3 novel distractors.

2.5.2 Short Stories subtest

The Short Stories subtest consisted of five short stories each followed by two questions. On each trial, the participant saw a silent video clip of either the male or female speaker telling a short story. The tester then asked the participant, in their preferred language, 2 questions about the story. The participant answered the question by selecting the correct picture from an array of four. The participants were given the following instructions: "Now you will see the man or woman say a short story. Then you will be asked two questions about the story. After each question, you will see four pictures and you have to answer by clicking on one of the pictures. We will practice first."

3 Validation and Standardisation study

The main aims of this study were to (1) validate ToCS as a measure of speechreading and (2) use ToCS to generate performance norms for speechreading ability in school-aged deaf and hearing children. In order to do this, the speechreading skills of 177 deaf and hearing children aged between 5 and 14 years were assessed using ToCS. All children had normal non-verbal IQ scores and no additional problems. There were no significant differences between the deaf and hearing children in their chronological age, non-verbal IQ or gender distribution. Both deaf and hearing children were evenly distributed across the age bands and were from similar ethnicities. The hearing children were recruited from the mainstream schools to which the deaf units were attached thereby ensuring that the groups were similar in terms of background demographic variables.

3.1 Deaf participants

86 severely and profoundly deaf children (47 boys and 39 girls) participated in this study. All deaf children had a prelingual, sensori-neural hearing loss greater than 70db (mean hearing loss 97.7db). The mean age was 9 years 6 months. The deaf children were from a range of language and communication backgrounds: 44 used spoken English; 33 used signing (26 BSL); 3 bi-lingual (speech and BSL) and the remaining 5 used total communication. 36 children were fitted with cochlear implants and the remaining (apart from 2) wore digital hearing aids.

3.2 Hearing participants

The hearing participants were 91 normally hearing children (38 boys and 53 girls). Their mean age was 9 years 1 month.

3.3 Reliability of ToCS

ToCS was found to have good reliability. The internal reliability, calculated using Cronbach's alpha, was α=0.8. A small group of children (n = 15) were administered ToCS again 3 weeks later and the test-retest reliability was found to be 0.89.

3.4 Validity of ToCS

The current closed set, picture response format of ToCS was validated as a method of measuring speechreading. 55% of the participants completed an additional subtest of ToCS: the Everyday Questions subtest. This was an open set of questions, whereby the participant saw a video clip of the man or lady asking them a question such as "what is your favourite colour?" or "what did you have for breakfast?" and the participant had to answer the question and repeat back what they thought has been asked. Performance on the Everyday Questions subtest was significantly correlated with scores on ToCS (r = .84, p<.001).

4 Standardisation results

In order to standardise the speechreading scores, the effects of certain demographic factors on the data were determined.

4.1 Hearing status

There were no significant differences between the deaf and hearing children in their overall performance on ToCS, F(1,172) = .06, ns, or in their performance across the subtests (F(2,344) = 0.14, ns). Figure 3 shows this clearly. This contradicts the findings of two recent research studies reporting a deaf advantage in speechreading for children [4] and adults [7] but supports past findings of comparable speechreading skills in deaf and hearing children (e.g. [1, 6]). A potential explanatory factor is that the deaf and hearing children in the current study and in both [1] and [6] were matched for chronological age rather than being matched for reading age as in [4].

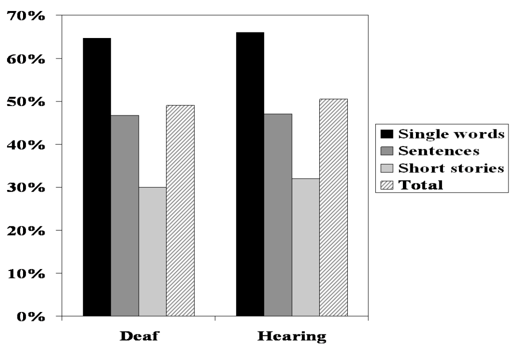

Figure 3: Mean percentage correct on the ToCS for deaf and hearing children

4.2 Psycholinguistic subtest

There was a main effect of psycholinguistic subtest, F(1.9, 344) = 542.5, p<.001, whereby both deaf and hearing children achieved higher scores on the single word subtest than both the sentences and short stories. As Figure 3 shows, the deaf and hearing children showed a remarkably similar pattern of performance across all three subtests of ToCS.

4.3 Chronological age

As shown in Figure 4, speechreading improved significantly with age for both deaf (r = .64, p<.001) and hearing children (r = .60, p<.001).

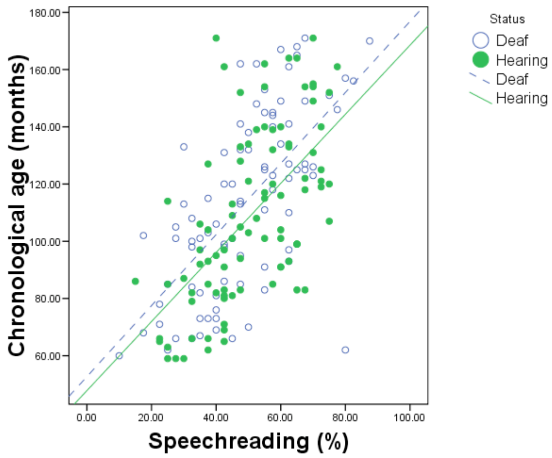

Figure 4: Scatterplot showing the effect of age on ToCS

4.4 Standardisation

The raw scores were converted into standardised scores, which will be made available to researchers and clinicians as part of the test. As there were no differences between the deaf and hearing children's performance across the different subtests of ToCS, and in their age, non-verbal IQ or gender, the deaf and hearing scores were combined for the purposes of standardisation.

5 Cognitive correlates of speechreading

Whilst collecting data for the validation and standardisation of ToCS, the cognitive correlates of speechreading in deaf and hearing school-aged children were also examined.

5.1 Non-verbal IQ

There was no significant association between non-verbal IQ (estimated with the Matrices subtest from the BAS II) and performance on ToCS for deaf or hearing children (r = -.01, ns and r = -.06, ns respectively). This is similar to previous findings with both children and adults.

5.2 Expressive vocabulary

Expressive vocabulary was assessed with the Expressive One Word Picture Vocabulary Test (EOWPVT). The deaf children were allowed to answer in their preferred language; spoken English, BSL or a combination of speech and sign. There was a small yet significant association between vocabulary and performance on ToCS in the deaf children (r = .27, p = .21), even after controlling for age and non-verbal IQ. Vocabulary was not significantly related to ToCS in the hearing children (r = .18, ns).

5.3 Reading ability

Even after statistically controlling for age and non-verbal IQ, performance on ToCS for both deaf and hearing children was significantly related to reading accuracy (r = .49, p<.001 and r = .31, p =.005 respectively). Figure 5 shows the relationship between speechreading and reading accuracy for deaf and hearing children.

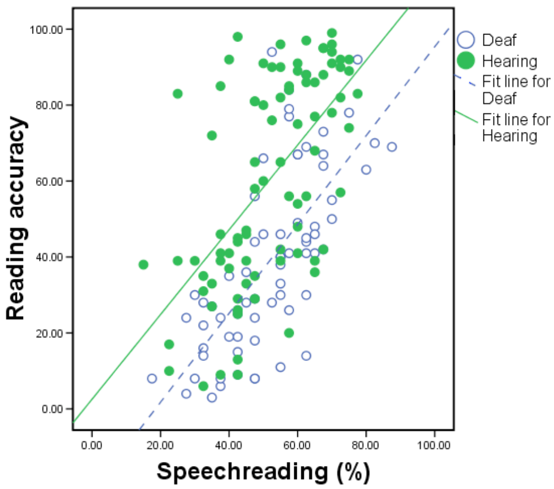

Figure 5: Scatterplot showing the relationship between ToCS and reading accuracy for deaf and hearing children

Likewise, Figure 6 shows the significant association between ToCS and reading comprehension observed in both deaf and hearing children (r = .44, p<.001 and r = .28, p =.01). These results confirm previous research findings (e.g. [5]) and extend the association between speechreading and reading ability to larger psycholinguistic units and indeed to hearing children.

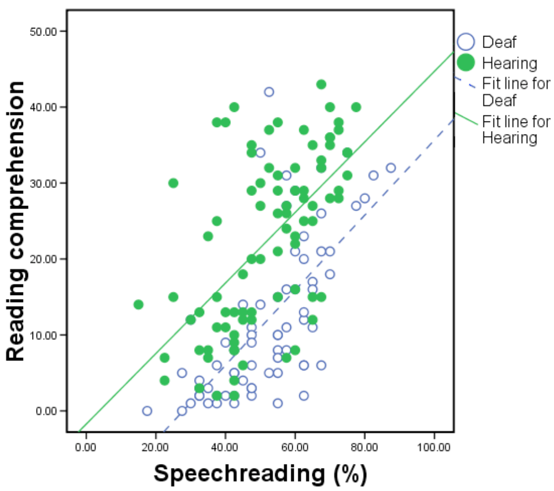

Figure 6: Scatterplot showing the relationship between ToCS and reading comprehension for deaf and hearing children

6 Summary and conclusions

- ToCS is a valid and reliable assessment of speechreading ability in school-aged children.
- ToCS is sensitive to deaf and hearing speechreading skills at different psycholinguistic levels.
- Speechreading showed improvement with age for both deaf and hearing children.
- ToCS scores were similar in deaf and hearing, despite higher vocabulary in hearing.
- For the deaf children, TOCS was related to productive vocabulary.
- Performance on ToCS was significantly related to reading accuracy and reading comprehension in both deaf and hearing children.

Why would speechreading be related to reading? One explanation is that the information derived through speechreading is likely to be incorporated into phonological representations. Therefore, better speechreading skills may result in more distinct and specified phonological representations which in turn can help children when learning to read.

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